

DISCUSSION

Introduction

The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort of the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, with support from the University of New Brunswick and the Canadian Hydrographic Service. The multibeam echo sounder survey was conducted on four cruises over a two-year period from the fall of 1994 to the fall of 1996. This map shows one of a series of 18 quadrangles (see location map) in which sea floor depth information is depicted in sonar-illuminated shaded relief view at a scale of 1:25,000, with topographic contours superimposed in blue. The image shows here uses a sun elevation angle of 45 degrees above the horizon from an azimuth of 200 degrees and a vertical exaggeration of four times. In effect, topographic relief is enhanced by having the sea illuminate the sea floor from a position 10 degrees west of north, so that shadows are cast on the southern flanks of seabed features. Some features in the images are artifacts of data collection. They are especially noticeable where the seabed is smooth, and they include small high and low and unusual-looking features and patterns that are oriented parallel or perpendicular to survey tracklines. For a depiction of the topographic contour alone, and for an explanation of survey and topographic data-processing methods, see the companion map by Valentine and others (1997). Topographic contour maps of all 18 quadrangles in the map series are available on a CD-ROM in PDF, PS, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exist.

Regional seabed features

The major topographic features depicted in the map series were formed by glacial processes. In broad terms, these features are interpreted here to represent a glacial history that developed in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediment to form the large basins, banks, ridges, and valleys. Many other features observed here represent the later stages of deglaciation. They are the result of processes at work when much of the area was covered by stationary retreating ice, and when at the same time small valley glaciers and ice falls were active in and near areas of high topographic relief. The sea invaded the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits were formed. Today, the sea floor is modified mainly by strong southwesterly-flowing bottom currents caused by storm winds from the northeast. These currents move sediments from the shallow banks and transport them into the basins. With time, the banks affected by these currents become coarser,

as sand and mud are removed and gravel remains; and the western flanks of the banks, as well as adjacent basins, are built up by deposits of mud and sand.

Quadrangle 16 features

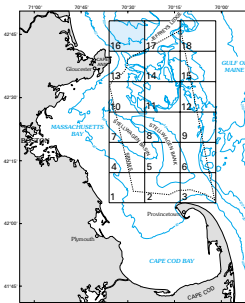
The south-central and southern part of Quadrangle 16 is a shallow bank that lies at water depths of 40 to 55 m. It is the western extension of a large bank (Jeffreys Ledge) that lies mostly in the adjacent Quadrangle 17 to the east (Valentine and others, 2001). The bank surface is gravel, including boulder piles and ridges, that is covered with a thin veneer of sand in low areas. The boulder ridges are a complex of glacial features that resemble lateral moraines (deposits of rock debris piled up at the edge of moving ice) and end moraines (deposits of rock debris piled up at the forward edge of the ice), and eskers (sand and gravel deposited by melting water in channels within stationary ice). Several large depressions on the bank (42°41.0' N, 70°28.4' W, and 42°40.9' N, 70°27.5' W) possibly mark the former locations of large masses of melting glacial ice. The bank is incised on its northern edge by a north-trending valley (42°42.5' N, 70°25.5' W) that is floored with sand in its head and muddy sand where it enters a large basin. From the southeast corner of the quadrangle the seabed slopes northward through water depths of 40 to 75 m. The bank surface is gravel to a water depth of approximately 55 m; below this depth, on the bank margin, the gravel is covered with a veneer of sand to 75 m. Low hills and elongate ridges extend northward from the eastern edge of the quadrangle into a large basin that occupies a major part of the region. The hills and ridges lie in water depths of 70 to 105 m. They are covered with gravel, including boulder piles and ridges. The gravel is covered in places with a veneer of sand that is more extensive on the sides of these features than on their tops.

A long, prominent ridge extends northward across the northern part of the quadrangle and past its northern boundary at 42°48' N. The ridge has a relief of 10 to 30 m in water depths ranging between 75 and 105 m except for a high hill at 70°25.5' W, near the northern edge of the quadrangle. The ridge is covered with gravel, including boulder piles and ridges, and its flanks are covered with a thin veneer of sand. On the ridge and to a lesser extent south and east of it, long, narrow grooves in the seabed that typically are 50 m to a maximum of 100 m wide (42°43.95' N, 70°27' W), less than 5 m deep, and up to a kilometer or more in length are interpreted to be marks made by the jagged bottoms of icebergs that gouged the seabed by grounding here during the late stages of the last glaciation. They are present at 70 to 95 m water depth. Similar grooves are also present in the adjacent Quadrangle 17 to the east. Outcrops of bedrock are present in the far

southwestern part of the quadrangle. They lie at 15 to 55 m water depth and are an extension of the rocks exposed on the coastline a mile to the west. The remainder of the sea floor in Quadrangle 16 is relatively smooth sandy mud and mud that is part of a large basin that ranges in depth from 20 m in the southeast to 115 m in the northeastern part of the quadrangle. Sediment in the basin becomes muddier with increasing water depth, and is underlain in the transition areas surrounding bedrock outcrops, gravelly banks, ridges, and hills. In several areas of the basin, the smooth mud seabed is interrupted by shallow depressions (for example, 42°43.05' N, 70°31.15' W, 42°43.65' N, 70°31.60' W, and 42°43.77' N, 70°31.00' W). The depressions are irregular in outline and up to several hundreds of meters in length, and some of them surround small mounds. Observations of similar features in Quadrangles 7 and 8 (Valentine and others, 1999a,b) have shown the mounds, in some places, to be patches of gravel, including boulders, that are heaped up by groundhills. The depressions in the mud are interpreted to have been formed by the scouring actions of groundhills that have exposed the gravel habitat and prevented its burial by basin mud.

REFERENCES CITED

- Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 16 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts. U.S. Geological Survey Open-File Report 97-729, scale 1:25,000.
- Valentine, P.C., Baker, J.L., Unger, T.S., and Pollon, C., 1998, Sea floor topographic map and perspective-view imagery of Quadrangles 1-18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts. U.S. Geological Survey Open-File Report 98-138, 1 CD-ROM.
- Valentine, P.C., Baker, J.L., and Unger, T.S., 1999a, Sonar-illuminated sea floor topography of Quadrangle 7 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts. U.S. Geological Survey Geologic Investigations Series Map I-2707, scale 1:25,000.
- Valentine, P.C., Unger, T.S., and Baker, J.L., 1999b, Sonar-illuminated sea floor topography of Quadrangle 8 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts. U.S. Geological Survey Geologic Investigations Series Map I-2708, scale 1:25,000.
- Valentine, P.C., Baker, J.L., and Unger, T.S., 2001, Sonar-illuminated sea floor topography of Quadrangle 17 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts. U.S. Geological Survey Geologic Investigations Series Map I-2717, scale 1:25,000.



Location map outlining the 18 quadrangles in this series. Quadrangle 16 shown in blue. Boundary of Stellwagen Bank National Marine Sanctuary (SBNSM) indicated by dashed line. Bathymetric contours in meters.

SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 16 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

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2001